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SOIL COMPACTION OF HARDIN HALL GREEN SPACE SOCIAL TRAIL ON THE UNIVERSITY OF NEBRASKA - LINCOLN'S EAST CAMPUS

by Danielle Jones

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ABSTRACT

Soil compaction is a common agricultural and urban landscape problem, particularly along cow paths and social trails, respectively. The social trail in the green space of Hardin Hall on the University of Nebraska- Lincoln East Campus has visual cues of soil compaction, due to the slow rate of water infiltration and lack of vegetation. Being the focus area of this study, a sampling grid was placed on the trail by measuring and sectioning it into equal sections. These sections were further divided into subsections of on-path and off-path for comparison. Soil structure, texture, bulk density, and water infiltration were analyzed to determine the severity of soil compaction occurring on this social trail. Both soil structure and soil texture were found to be the same when comparing on-path and off-path samples. Bulk density was found to be significantly ($p < 0.001$) higher for the on-path samples compared to off-path samples. Water infiltration rates were also significantly ($p = 0.002$) slower for the on-path samples compared to off-path samples. These results indicate that, due to being the same on- and off-path, soil structure and texture can be excluded as a cause for the difference of bulk density and water infiltration rates. Significantly higher bulk densities and slower water infiltration indicate that soil compaction is occurring on the Hardin Hall social trail.

INTRODUCTION

Soil compaction is a problem commonly associated with agriculture. This is generally due to heavy equipment being used to sow, apply fertilizers, harvest, and till causing soil particles to condense leaving smaller pore space. This leads to difficulties with water, nutrients, and biological entities, such as bioturbators and roots, penetrating the soil horizons (Hamza and Anderson, 2005). Another element that produces soil compaction is intensive grazing (Hamza and Anderson, 2005). This occurs when livestock is distributed and moved to particular locations to graze (SDAF, 2008). The trampling of the soil by the grazing animals results in the breakdown of soil structure, a contributing factor of soil compaction. This effect, not unlike that of busy urban areas, where social trails are continuously used by passer-byers. Social trails are paths developed by erosion caused by animal or human footfall, usually represents the shortest or most easily navigated route between an origin and destination (Boyd, 2016).

New research has shown that the problem of soil compaction is not exclusive to agriculture, but also affects urbanized areas. Though not being an obstacle when it comes to producing food for the masses, soil compaction in urban areas does account for problems pertaining to city planning and landscape management (Jim, 1998). Soil compaction in urban areas also has similar effects to the soil properties and processes noted in compacted agricultural soils. Soil texture, structure, bulk density, and water infiltration are factors that can help identify or quantify compaction in soil (DeJong-Hughes and et al., 2001). For instance, soil compaction in urbanized areas reduce infiltration rates and plant root penetration (Day and Bassuk, 1994; Jim, 1998). As a result, decreasing the levels of infiltration rates create problems for city planners due to increased levels of stormwater runoff. In urban areas, this can lead to flooding and contamination of storm waters that enter groundwater systems (Gregory et al., 2006). Along with these issues, landscape managers have trouble getting roots to penetrate these layers of compacted soils, along with the infiltration of nutrients and water to be accessible to plants. These issues often result in unpleasant aesthetic landscapes (Day and Bassuk, 2004).

As previously mentioned, soil compaction occurs when people create their own pathways by cutting through grass and plant beds for a more convenient route than the designated paved walkways. Over time, the vegetation is worn away and attracts even more use. This action of creating social trails commonly occurs on the University of Nebraska - Lincoln (UNL) East Campus. Three main examples of this occur across East Campus, as noted by Hersh (2015). Most notably on the Hardin Hall green space (Hersh, 2015), which was the focus area for this project. The level of soil compaction in contrasting on-path and off-path locations of the Hardin Hall social trail was determined by analyzing the structure, texture, bulk density, and water infiltration rates of these soils. A few assumptions were in place in order to have conducted this study. The first assumption was that I had enough previous experience and exposure with the process and knowledge to accurately evaluate texture and structure of soil. The second assumption was that the pathway, since last measures were taken, had the same amount of traffic with no disturbances due to construction.

The overall purpose of this study was to create a further understanding of how soil compaction in urban areas affects the characteristics of soil, and to produce information for UNL landscape managers to help remediate the situation. The objective of this study was to obtain better basic understanding of the effects of compaction to UNL social trails through a more detailed collection of data of soil properties commonly associated with soil compaction. The results of the on-path and off-path comparisons were used to draw conclusions about the level of soil compaction on the Hardin Hall green space.

METHODS & MATERIALS

Research conducted in 2014 by Alainie Hersh helped determine the methodology of sampling that took place during the research conducted. Due to her dissatisfaction of her methodology and results, standard soil sampling and analysis techniques were used. In contrast to the three paths studied by Hersh (2015), one path, the social trail in the Hardin Hall green space, was selected as the main focus of this study. The path's length was measured at 210 feet and divided into five equal lengths of 50 feet, excluding 5 feet at either end of the path where the path was very diffused and difficult to distinguish. These five sections were labeled A through E, and were divided horizontally into three smaller sections of 5 feet, with one section on either side of the path (off-path) and one on the path (on-path) to create a grid-like sampling area (Figure 1). These subsections were labeled from left to right with a section letter followed by 1, 2, 3 (Figure 1). Flags were used to identify where the plane of measurement was with the least amount of compaction and soil displacement as possible. Section C was sampled more than the three times (Figure 1), so an average, or control, could be calculated to ensure data was not skewed or inaccurate. This section was sampled with two additional samples on the path and two additional samples on one side of the path. Soil samples collected at each location were analyzed for soil structure, texture, bulk density, and water infiltration.

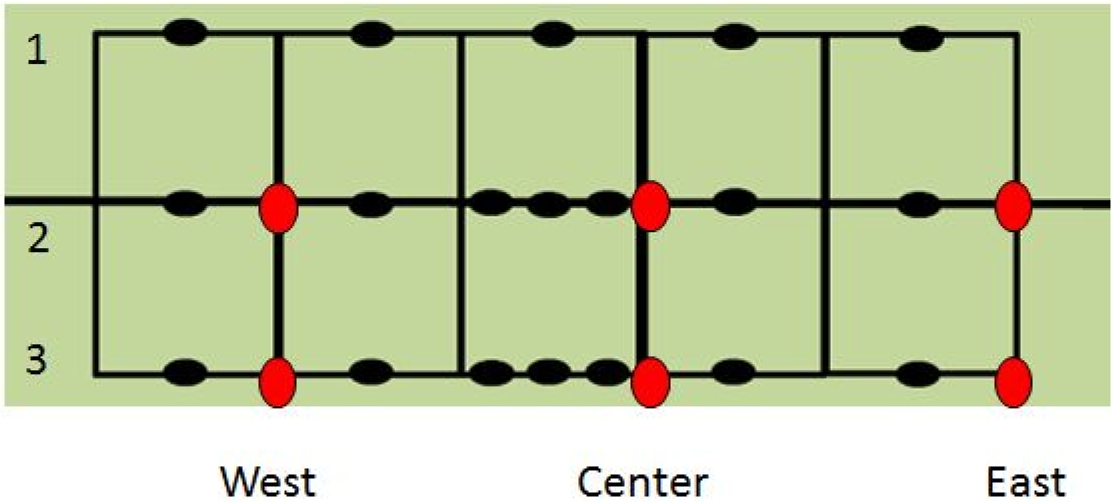

Figure 1. Soil sampling design along the Hardin Hall social trail. The black dots represent where samples were taken to determine soil structure, texture, and bulk density. The red dots represent locations where water infiltration tests were performed.

Soil structure was visually observed and recorded after the samples were collected for texture and bulk density, along with secondary visual assessments of the samples themselves when transferring from the sampling baggies to the drying containers. The *Field Book for Describing and Sampling Soils* (Schoeneberger et al., 2012), which contains precise measurements and dimensions, was used as a source of reference for structure.

Samples were collected from on-path and off-path locations (Figure 1) to determine soil texture. Soil particle size distribution (PSD), the relative amounts of sand, silt, and clay components, was determined via laser diffraction (Sperazza, 2004). The PSD percentages, along with the NRCS standard soil textural triangle, were used to identify the correct soil texture. Hand texturing was used to confirm these results.

Following the *USDA NRCS Soil Survey Laboratory Methods Manual, Version 4.0* (Burt, 2004), and assisted by one of its scientists, Steve Monteith, bulk density was sampled by inserting a 3” x 4.5” core into the ground and carefully removing the core from the ground with as much soil inside the core as possible. Excess soil was removed from the edges and outside of the core, and the soil sample was placed into a labeled sampling bag. Samples were weighed in the laboratory at field-moist state, were then air dried and weighed, and then oven dried and weighed. The volume of the core was also recorded. The core volume and oven-dry weight of the samples were used to calculate bulk density as follows:

Bulk Density (g/cm^3) = Oven-dry Weight of Soil (g) / Volume of Soil Core (cm^3).

Finally, water infiltration rates were determined with the standard method also noted the *USDA NRCS Soil Survey Laboratory Methods Manual, Version 4.0* (Burt, 2004). Infiltration rings were inserted into designated locations within the sampling area (Figure 1). Plastic film was used to prevent surface sealing that could have been created with the impact of water onto soil. 1 inch of water (500 mL), was placed on top of the plastic and a timer was used to record the amount of time it took for the water to infiltrate into the ground. A standard of moisture was set by doing one trial before recording the second trial for the study.

Statistical analysis was performed on the bulk density and water infiltration comparisons. An initial F-test was used to determine if variances between on-path and off-path results were equal. A t-test was used to determine there was a significant difference between on-path and off-path averages. The p-values were used to determine how strong the difference was between each significant difference.

RESULTS & DISCUSSION

Structure

Soil structure for all sample sites were determined to be a weak sub-angular blocky structure (Figure 2). Typically, in compacted soils structure is observed to be platy (Duiker, 2013). The lack of difference between on-path and off-path samples indicates that only a low level, or no, compaction has occurred when using this soil property as a reference. The structure was only observed at the depth of the bulk density soil core and thus could have been different deeper in the profile, which future studies should investigate in a more horizontally and vertically extensive profile.

Figure 2. An example of sub-angular blocky structure compared to the actual structure

Texture

Laser diffraction analyses indicated that on-path and off-path soils had nearly identical particle size distributions (Table 1). Hand texturing and the standard soil textural triangle identified these soils as having a silty clay loam texture. Due to the lack of difference between on- and off-path indicates that any difference in the bulk density and water infiltration rates are not contributed to difference of texture, which is known to influence soil porosity and permeability (Brady and Weil, 2016). In future studies, investigation of more horizontally and vertically extensive profiles should be done to measure textures of lower depths, where water infiltration tests were ran, due to the effects of coarse and fine textures on the rate of water infiltration.

Sediment Size	**Particle Size Distribution (PSD)**	
	On-Path	**Off-Path**
Clay	29.5	29.0
Silt	66.4	66.5
Sand	4.1	4.5

Table 1. Average soil particle size distributions of on-path and off-path sampling locations.

Bulk Density

In the bulk density tests, on-path samples had significantly ($p < 0.001$) higher bulk densities than the off-path samples. As noted earlier, structure and texture were the same on- and off-path, meaning, theoretically, that bulk density should not be different on- and off-path. The significant difference in the bulk densities is an indication of soil compaction occurring on the social trail. A bulk density of >1.6 g/cm^3 indicates severe compaction, though the soils on the social trail were not calculated to have bulk densities between 0.802 g/cm^3 and 0.869 g/cm^3 (Figure 3). Thus, while not at a severe level, there is now some soil property evidence to support the visual observations of soil compaction occurring along the Hardin Hall social trail.

Figure 3. Bulk densities of sampling locations along the Hardin Hall green space social trail.

Water Infiltration

A significant (p = 0.002) difference was also noted in the amount of time for water to infiltrate between on- and off-path samples (Table 2). It was noted earlier that the soil texture is the same on- and off-path, which would theoretically mean that water infiltration should occur at similar rates. The data collected in this study, however, indicates severely impeded water infiltration in the on-path locations. Slower water infiltration rates would affect the availability of water for plant roots, which could lead to poor plant health and, potentially, plant death. These factors would affect landscape management practices, particularly pertaining to appropriate plant selection.

	On-Trail Water Infiltration (Minutes)	Off-Trail Water Infiltration (Minutes)
West	90+	17
Center	90+	13
East	90+	25

Table 2. Water infiltration, in minutes, of 1 inch of water in on-path and off-path sampling locations.

CONCLUSION

Soil compaction is becoming a common landscape management problem in urban areas, including UNL East Campus. Investigating the soil properties such as structure, texture, bulk density, and water infiltration on and off of the Hardin Hall social trail has provided scientific backing that soil compaction is occurring in the area, though not yet at a severe level. Structure and texture were concluded to be the same on and off of the social trail, whereas bulk density was significantly ($p < 0.001$) higher and water infiltration was significantly ($p = 0.002$) slower on the social trail compared to off-path samples. Compaction has been visible on the Hardin Hall green space social trail for at least five years, but now has some scientific support. Landscape managers, such as UNL landscape services, could use the information provided in this study to conduct a more detailed soil compaction study of the Hardin Hall social trail, and other UNL East Campus social trails, and determine appropriate future remediation and management strategies of prevention of further soil compaction.

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